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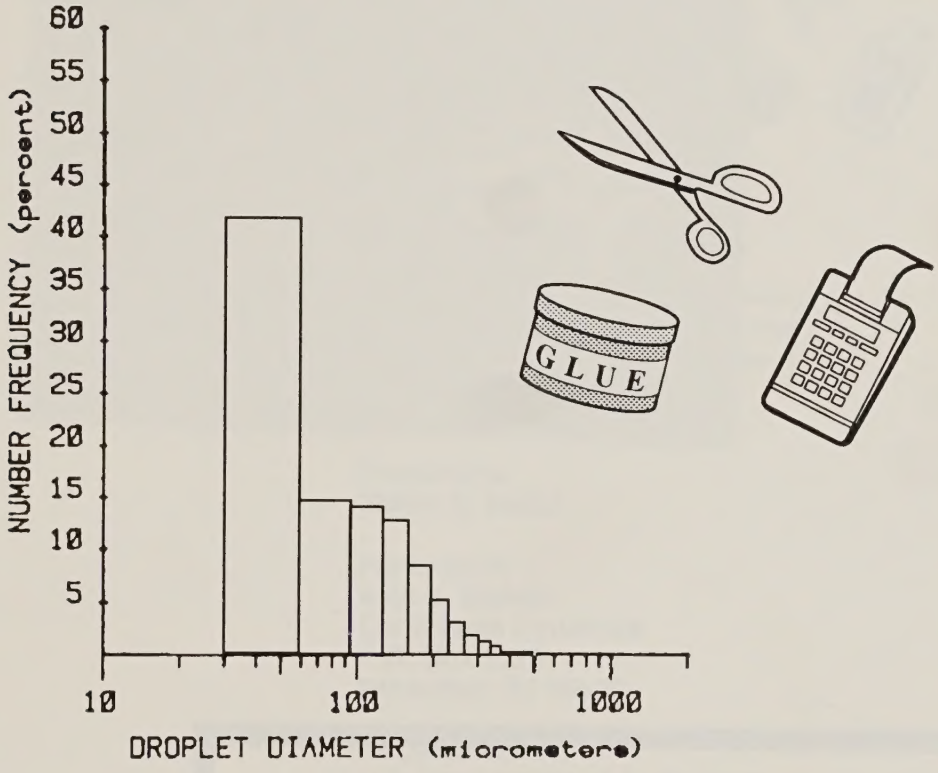
SDC: Size Distribution Calculation *User Manual*



Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

SDC:
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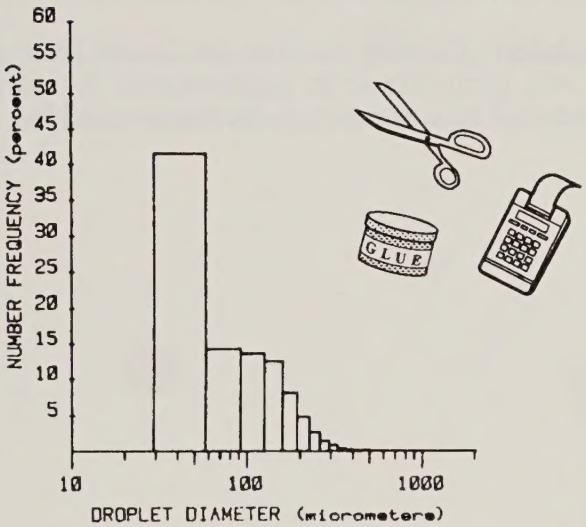

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Contents

Foreword

This report is published as a part of the USDA Forest Service program to improve aerial application of pesticides specifically by using pesticides and delivery systems tailored to the forest environment. The program is conducted jointly by the Technology and Development Center, Missoula, MT, and the Forest Pest Management Staff, Washington Office at Davis, CA, under the sponsorship of State and Private Forestry.

Details of the aerial application improvement program are explained in two Forest Service reports: *A Problem Analysis: Forest and Range Aerial Pesticide Application Technology* (Equipment Development Center Rpt. 7934 2804, July 1979, Missoula, MT) and *Recommended Development Plan for an Aerial Spray Planning and Analysis System (*Forest Pest Management Rpt FPM 82-2, February 1982, Davis, CA).

The study was conducted as part of Program WIND (winds in nonuniform domains). Authority for the cooperative program is the *Supplemental Agreement, dated February 1985, to the master Memorandum of Understanding Between U.S. Department of Defense and U.S. Department of Agriculture Relative to Cooperation With Respect to Food, Agriculture, and Other Research of Mutual Interest.*

Introduction

SDC (Size Distribution Calculation) is a program written to permit the code user to enter wind tunnel drop size distribution data and combine them into reduced input data sets that can be run with USDA Forest Service deposition codes AGDISP (Ref. 1) and FSCBG (Ref. 2). SDC runs on personal computers and the USDA Forest Service Data General.

Drop size distribution categories from a wind tunnel test will not generally match drop size categories obtained from card analysis. A compendium of nozzle drop size distributions may be found in Ref. 3. The data set from which all discussion will follow may be found in Ref. 4, reproduced here as Table 1.

Table 1: Typical Drop Size Wind Tunnel Distribution Dataset (Ref. 4)

Nozzle	D8-45
Angle to Airstream	0 degrees
Spray Pressure	40 psi
Airspeed	50 mph
Flow Rate	.88 gpm
Tank Mix	33.3% GLYCERINE
	66.6% WATER

UPPER LIMIT	N(RAW)	N/SEC	Gm/SEC	% N	% VOL	ACCUMULATED % N	ACCUMULATED % VOL
56	3376	1.35E+07	0.44	52.28	0.54	52.28	0.54
89	5418	2.92E+06	0.58	11.31	0.70	63.59	1.24
122	5203	2.48E+06	1.50	9.57	1.82	73.17	3.06
154	4536	2.06E+06	2.82	7.96	3.41	81.12	6.47
187	2826	1.25E+06	3.24	4.84	3.92	85.96	10.40
220	1768	836715	3.66	3.24	4.43	89.20	14.83
252	1215	618695	4.22	2.39	5.11	91.59	19.94
284	865	475469	4.78	1.84	5.79	93.43	25.72
318	724	417476	6.00	1.61	7.27	95.04	32.99
351	574	323632	6.33	1.25	7.67	96.30	40.66
382	437	237844	6.07	0.92	7.36	97.22	48.02
414	380	213973	7.04	0.83	8.53	98.04	56.55
447	288	156021	6.50	0.60	7.88	98.65	64.43
479	202	100298	5.20	0.39	6.30	99.03	70.73
512	132	69685	4.43	0.27	5.36	99.30	76.09
545	109	57107	4.40	0.22	5.33	99.52	81.42
578	81	47832	4.42	0.18	5.35	99.71	86.77
611	47	23446	2.57	0.09	3.11	99.80	89.88
644	44	21846	2.82	0.08	3.41	99.88	93.29
677	20	9121	1.37	0.04	1.66	99.92	94.96
710	17	7685	1.34	0.03	1.62	99.95	96.58
743	10	8861	1.77	0.03	2.15	99.98	98.72
776	3	1513	0.35	0.01	0.42	99.99	99.14
809	1	2389	0.62	0.01	0.75	100.00	99.90
842	1	293	0.09	0.00	0.10	100.00	100.00
TOTAL	2.83E+04	2.59E+07	82.55				

NUMBER MEAN DIA.=	D(10)	100.90 microns
VOLUME MEAN DIA.=	D(30)	182.76 microns
SAUTER MEAN DIA.=	D(32)	308.06 microns
	D(N.1)	<56 microns
NUMBER MEDIAN DIA.=	D(N.5)	<56 microns
	D(N.9)	230.57 microns
	D(V.1)	183.97 microns
VOLUME MEDIAN DIA.=	D(V.5)	389.66 microns
	D(V.9)	611.63 microns

Code Operation

SDC works with data that include the lower bound (previous upper bound) and the upper bound drop diameters (in microns) and their mass fractions. The "UPPER LIMIT" and "% VOL" columns from Table 1 are the two columns of information entered into SDC. The initial SDC screen is shown in Table 2. The SDC columns represent the following:

"#N": Drop size class number; for reference only.

"Upper D": Upper drop diameter (in microns) of the drop size class (UPPER LIMIT in Table 1).

"Mass F": Mass fraction in the drop size class (% VOL in Table 1 divided by 100).

"Avg D": Average drop diameter (in microns) of the drop size class, spanning the previous drop size class upper drop diameter (the lower drop diameter of this class) to this drop size class upper drop diameter, computed by the fourth-power formula in Ref. 5 (the first drop size class is assumed to have a lower drop diameter of zero). That formula is:

$$\text{Avg D} = \left[\frac{D_U^4 - D_L^4}{4 (D_U - D_L)} \right]^{1/3}$$

where

D_L = lower drop diameter

D_U = upper drop diameter.

The SDC options available are the following:

"Help" (H): Summarizes all options available in SDC (Table 3).

"Loadfile" (L): Loads a previously created drop size distribution datafile for further manipulation. The filename must contain the Filename and Extension if appropriate (no defaults are assumed by SDC).

"Savefile" (S): Saves the current drop size distribution into a datafile (these datafiles may be printed or typed). The filename must contain the Filename and Extension if appropriate (no defaults are assumed by SDC).

"Delete" (D): Deletes an existing drop size class from the current drop size distribution.

"Insert" (I): Adds a new drop size class to the current drop size distribution.

"Modify" (M): Changes the values of "Upper D" and/or "Mass F" in an existing drop size class for the current drop size distribution.

"Combine" (C): Adds together two or more existing drop size classes to form a new drop size class for the current drop size distribution.

"Generate" (G): Creates a new drop size class by setting specific lower and upper drop diameters on the current drop size distribution and combining all drop diameters between the defined limits.

"eXit" (X): Exit from SDC.

All of these options are invoked by single letters as highlighted above. In the personal computer version, entry of any option will be interpreted without the need for a return keystroke (the Data General version requires a return keystroke). A completed screen, entering all of the necessary data from Table 1, is shown in Table 4. The savefile contents are displayed in Table 5.

The SDC screen also contains "Tot Mass" a running total of the mass fraction, which should sum to 1.0 if all of the tunnel data is entered (for sums greater than 1.0 the program will display "SumErr"). An option may be aborted by the Escape key on a personal computer, and any Function key on the Data General. A return keystroke without data entry is interpreted as a data entry of 0. The program is invoked with the entry of SDC on a personal computer, and an entry of X SDC on the Data General.

An application of the data from Table 4 is the Program WIND Phase III (EMCOT) data runs with card data collected in 100 micron increments. Those results are shown in Table 6, and have been used as input for code validation (Ref. 6).

SDC will trap the following errors and inconsistencies:

"Cannot combine size classes": If the current drop size distribution is null, SDC will have nothing to combine.

"Cannot generate size classes": If the current drop size distribution is null, SDC will have nothing to generate.

"Delete after combining": After a combine operation, SDC will not permit the code user to delete data.

"Delete not possible": If the current drop size distribution is null, SDC will have nothing to delete.

"Existing data not saved": If the code user exits without savefiling the current drop size distribution, SDC will ask for confirmation before exiting.

"Insert after combining": After a combine operation, SDC will not permit the code user to insert data.

"Modify after combining": After a combine operation, SDC will not permit the code user to modify data.

"Must span a size class": SDC cannot generate a new size class unless the new class spans across two existing size classes.

"No data to modify": If the current drop size distribution is null, SDC will have nothing to modify.

"No need to save": If the code user attempts to savefile the current drop size distribution that has already been savefiled, SDC will prevent this unnecessary operation.

"Not found": If a desired loadfile cannot be located, SDC will signal this fact before proceeding.

"Not valid": If a desired savefile name is entered incorrectly, SDC will signal this fact before proceeding.

"Old data not saved": If the loadfile option is invoked with data present that has not been savefiled, SDC will ask for confirmation before loading.

"Option not available": The code user invoked an option that does not exist in SDC.

"Size class limit reached": No more than 36 drop size classes are possible in SDC.

"Value error": SDC will trap a variety of poor data entry values:

1. Drop diameters must be between zero and 5000 microns.

2. Mass fractions must be between zero and one.

3. Drop size classes must exist before being modified, deleted or combined.

4. Only neighboring drop size classes may be combined.

5. Drop size classes cannot be generated beyond existing data.

Table 2: SDC Initial Screen

```
Continuum Dynamics, Inc.                Size Distribution Calculation (SDC) 1.0
Options      #N   Upper D   Mass F      Avg D   #N   Upper D   Mass F      Avg D

Help        |
            |
Loadfile    |
Savefile    |
            |
Delete      |
Insert      |
Modify      |
            |
Combine     |
Generate    |
            |
eXit        |
            |
Tot Mass    |
 0.0000     |
            |
            |

Enter option:
```

Table 3: SDC Help Screen

```
Continuum Dynamics, Inc.                Size Distribution Calculation (SDC) 1.0
Options      #N   Upper D   Mass F     Avg D   #N   Upper D   Mass F     Avg D

Help        | Display information on SDC
            |
Loadfile    | Load a size distribution from an SDC file
Savefile    | Save the current size distribution in an SDC file
            |
Delete      | Delete an existing size class
Insert      | Insert/add a new size class
Modify      | Change the values in an existing size class
            |
Combine     | Add together several existing size classes
Generate    | Generate a size class between two diameters
            |
eXit        | Exit from SDC
            |
Tot Mass    | SDC displays, modifies and combines up to 36 size classes
 0.0000     | generated from wind tunnel data.  Minimum diam = 0.0 microns.
            | Upper D = upper diam.  Mass F = mass fraction.
            | Avg D = average diam (computed).  <ESC> aborts option.

Enter option:
```

Table 4: SDC Screen with Table 1 Inputs

```
Continuum Dynamics, Inc.                    Size Distribution Calculation (SDC) 1.0
Options      #N   Upper D    Mass F     Avg D   #N   Upper D    Mass F     Avg D

Help       |  1:     56.0    0.0054     35.28 | 19:    644.0    0.0341    627.64
           |  2:     89.0    0.0070     73.73 | 20:    677.0    0.0166    660.64
Loadfile   |  3:    122.0    0.0182    106.35 | 21:    710.0    0.0162    693.63
Savefile   |  4:    154.0    0.0341    138.62 | 22:    743.0    0.0215    726.63
           |  5:    187.0    0.0392    171.03 | 23:    776.0    0.0042    759.62
Delete     |  6:    220.0    0.0443    203.95 | 24:    809.0    0.0075    792.61
Insert     |  7:    252.0    0.0511    236.36 | 25:    842.0    0.0011    825.61
Modify     |  8:    284.0    0.0579    268.32 |
           |  9:    318.0    0.0727    301.32 |
Combine    | 10:    351.0    0.0767    334.77 |
Generate   | 11:    382.0    0.0736    366.72 |
           | 12:    414.0    0.0853    398.21 |
eXit       | 13:    447.0    0.0788    430.71 |
           | 14:    479.0    0.0630    463.18 |
Tot Mass   | 15:    512.0    0.0536    495.68 |
 1.0000    | 16:    545.0    0.0533    528.67 |
 ------    | 17:    578.0    0.0535    561.66 |
           | 18:    611.0    0.0311    594.65 |

Enter option:
```

Table 5: Savefile Listing of Table 1 Inputs

0.0	56.0	0.0054	35.28
56.0	89.0	0.0070	73.73
89.0	122.0	0.0182	106.35
122.0	154.0	0.0341	138.62
154.0	187.0	0.0392	171.03
187.0	220.0	0.0443	203.95
220.0	252.0	0.0511	236.36
252.0	284.0	0.0579	268.32
284.0	318.0	0.0727	301.32
318.0	351.0	0.0767	334.77
351.0	382.0	0.0736	366.72
382.0	414.0	0.0853	398.21
414.0	447.0	0.0788	430.71
447.0	479.0	0.0630	463.18
479.0	512.0	0.0536	495.68
512.0	545.0	0.0533	528.67
545.0	578.0	0.0535	561.66
578.0	611.0	0.0311	594.65
611.0	644.0	0.0341	627.64
644.0	677.0	0.0166	660.64
677.0	710.0	0.0162	693.63
710.0	743.0	0.0215	726.63
743.0	776.0	0.0042	759.62
776.0	809.0	0.0075	792.61
809.0	842.0	0.0011	825.61

Table 6: SDC Screen with Combined Results for 100 micron Drop Size Categories

```
Continuum Dynamics, Inc.                    Size Distribution Calculation (SDC) 1.0
Options      #N   Upper D   Mass F     Avg D   #N   Upper D   Mass F     Avg D

Help       |  1:    100.0   0.0185     63.00
           |  2:    200.0   0.1029    155.36
Loadfile   |  3:    300.0   0.1700    253.29
Savefile   |  4:    400.0   0.2368    352.37
           |  5:    500.0   0.2132    451.84
Delete     |  6:    600.0   0.1470    551.51
Insert     |
Modify     |
           |
Combine    |
Generate   |
           |
eXit       |
           |
Tot Mass   |
 0.8884    |
 ------    |
           |

Enter option:
```

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2. T. B. Curbishley and P. J. Skyler 1989: "Forest Service Aerial Spray Computer Model -- FSCBG (PC) User Manual for Version 3.04," USDA Forest Service Forest Pest Management Report No. FPM-89-1.

3. W. E. Yates, N. B. Akesson and R. E. Cowden 1984: "Measurement of Drop Size Frequency from Nozzles Used for Aerial Applications of Pesticides in Forests," USDA Forest Service Equipment Development Center Report No. 8434 2803.

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5. G. Herdan 1960: Small Particle Statistics, Buttersworths, London, p. 33.

6. M. E. Teske 1989: "An Examination of AGDISP Helicopter Model Comparisons with Data and Detailed Helicopter Code Predictions," Continuum Dynamics, Inc. Technical Note No. 89-01.